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New wind turbine manufacturing techniques

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Abstract

The development of wind energy has shown many positive effects on the economy, not just as a clean energy without greenhouse gases. It is also an internal energy that reduces the price of electricity in the markets. With this scenario, wind turbine manufacturers have developed modern turbines more powerful that harness less intense winds. These circumstances make it necessary to increase manufacturing capacity of the turbines in all processes involved.

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1. Introduction

One of the priorities in global energy policy is the development of alternative energy that reduces the emission of greenhouse gases. The result of these policies is to highlight the strong development of wind energy, given its low environmental impact and is an internal power source that generates positive effects on the market by reducing the price of electricity. Despite a higher initial cost, wind technology leads to increased profitability for the economy by generating local added value, creating a positive effect on the market by reducing electricity prices because the cost of wind is zero and the producers of wind energy can provide cheaper than other fossil fuel technologies. These circumstances have forced manufacturers of wind turbines to develop newer and more powerful machines to significantly increase its electric production capacity. Advances in the efficiency of wind turbines have focused on four main objectives:

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- Increased rated power of each wind turbine
- Harness the energy of the less intense winds
- Developed techniques that increase the capacity of integration and connection to existing electrical grids.
- Increase the reliability of the wind turbine

Given this scenario, turbine manufacturers need to increase manufacturing capacity of its production plants in all the processes involved. For this, integrated within the organization the resources of the components for industrial production, through acquiring other companies and signing contracts with different strategic partnership. So supplies are secured in the final production line. These processes resulting production must be perfectly framed in the efficiency factors, cost, worker safety and productivity, without being there any reduction in the final quality [1]. This industrial capacity is an efficient way that allows control the production process of the wind turbine (figure1).

Fig 1. Elementary factors of the production process

2. Methodology

To increase power and use of less intense winds is necessary increase the size of the wind turbine and this involves redesigning all (structural, mechanical, electrical and electronic) components, and as is logical, increase in size and mass. The manufacturing process of machine models predecessors to this trend, as they were of smaller sizes, could be mounted entirely manually, looking more like a machine shop that a manufacturing plant. The development of automation process generates many benefits. Robotics provides a significant reduction costs, increases productivity and dramatically improves the quality of final product [2]. Today, manufacture new models would not be possible without this working way. The different parts of a wind turbine in which progress is being made in manufacturing systems are shown in the following figure:

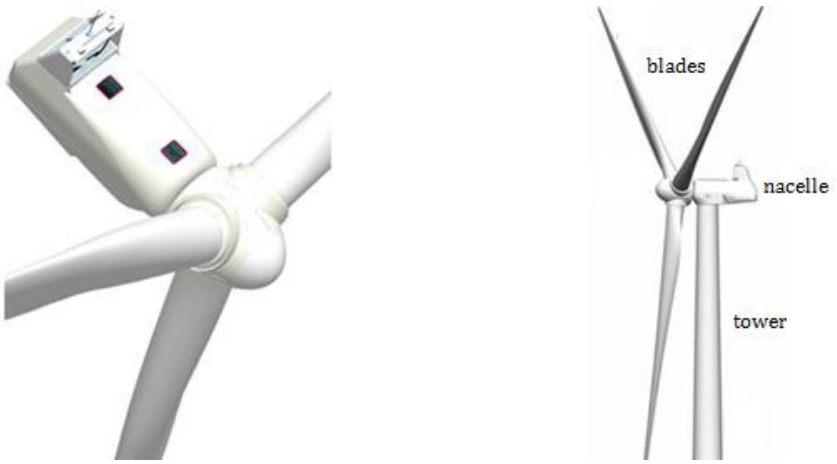

Fig 2. Parts of a wind turbine

2.1 Tower manufacture

To construct a tower, fan-shaped plate segments are cut from rectangular parent steel plates and roll-formed and welded into cone sections. A section's thickness may vary from 8 mm at the top to 65 mm at the base, depending on loads and steel grades used. Offshore installations usually use thicker or stronger plates. Also, taller towers mean maximize yield. The new integrated manufacturing systems of tubular wind turbine tower are based on the application of high power laser technology for the process of longitudinal and circumferential welding of various parts that make up the sections of the towers. To meet the requirements of accuracy and repeatability, it is necessary to work about the manufacturing processes and developing solutions with high technological value which allow increasing productivity and improving the structural quality, with the development of the following technologies:

- Development of a system for measuring and monitoring dimensional process formed, development of a process control system and development of an expert software system for automatic configuration of the bending machine during the process.
- Development of a monitoring and control system that allows automating the panned process between ferrules.
- Taking advantage of accuracy and quality provided by the previous developments, development of a welding process based on high-power laser technology combined with arc welding processes for the manufacture of wind turbine towers.

Also now can mounted wind turbines with precast concrete towers. These provide great stability, greater structural damping and agility during transport to overcome restrictions associated with taller towers. Has more internal space, facilitating the anchoring of the elements and equipment in the interior walls of the tower. The joints between sections need no screws, therefore, lacks maintenance. For the production of concrete segmental, simple means are needed (bridge cranes, steel molds, templates) and very similar processes to those of other manufacturing prestressed concrete plants. A good solution to support large wind turbines is the option to mount hybrid towers. These are formed in the lower section by concrete, and at the top, a metal structure is coupled. The combination of materials achieves a more rigid base and flexible top. These towers allow greater heights and mitigate vibrations.

2.2 Blade manufacture

The blades are the wind turbine component that captures wind energy to transform it into a rotary motion which is subsequently converted into electrical energy, and are a critical component to the overall performance, reliability and cost of a wind turbine. Longer blades increase the energy yield of a turbine. They sweep a larger area and so capture more wind. Not long ago, the manufacturing process of the blades was essentially manual. This craftsmanship form, simply make it impossible to develop more powerful and reliable wind turbines. Over time, there have been technological advances associated with methods that facilitate tasks and add high-quality to the final product. The main areas that allow the development of systems for wind turbine blade manufacturing are:

- Automating processes to shorten cycle times, improve accuracy and repeatability, and drive down costs.
- Using high performance composites with the support of relationships with strategic suppliers.
- Ultra-precise molding and assembly systems, using advanced tooling systems.
- Strongest advanced technology in vacuum infusion process to create lighter, and more reliable composite structures.
- Sophisticated measurement, inspection, testing and quality assurance tools, employing the most capable laser, ultrasonic, and other technologies to validate, verify, and ensure accuracy and near quality to the aerospace blades.

These advances in the manufacturing process, allow increasing the complexity of the geometry of the blade, enabling you to exploit the internal aerodynamic properties, and significantly increase energy

production. Also, the blades are less susceptible to turbulence and offer a uniform flow profile, thereby increasing reliability. Robotize different finishing processes allows a perfect protection against inclement weather such as wind and water, ultraviolet radiation or aggression caused by erosion and mechanical bending stresses. This is because the robot can traverse the full length of the blade in a single step without stopping

Fig 3. Painting robots for wind turbine blade

Besides improving the final finish, the automation of these processes avoids health problems for workers, preventing its exposure to the phases of grinding and applying paint to surfaces.

2.3 Nacelle manufacture

The nacelle is the part of the turbine where it houses and supports most of the elements of the wind turbine. Consists of a chassis to which are fixed the main constituent components of the wind turbine, shown in Figure 4. The nacelle is covered by composite panels to protect these components from environmental action.

The supply of components such as gearbox, alternator and power electronics is done through specialized external suppliers. In many cases, these manufacturers are integrated within the organization itself, either because they were acquired or because it has signed a strategic partnership. Thus the provision of these components is secured in the final production line [3]. Similarly ensures the supply of spare parts to develop proper maintenance [4]. With this capability, is achieved comprehensive control of the production process of the wind turbine, with this capability, is achieved comprehensive control of the production process of the wind turbine, remaining cost factors and productivity perfectly framed, being maximized the final quality levels and shortening the delivery times.

As for the assembly of components of the nacelle, the optimize the production organization is a key strategy that brings more quality and competitiveness due to factors such as homogenization, accuracy, production speed, production scheduling, increased standards quality and continuous reduction of waste [5]. For mounting process, have been pursuing the following strategies:

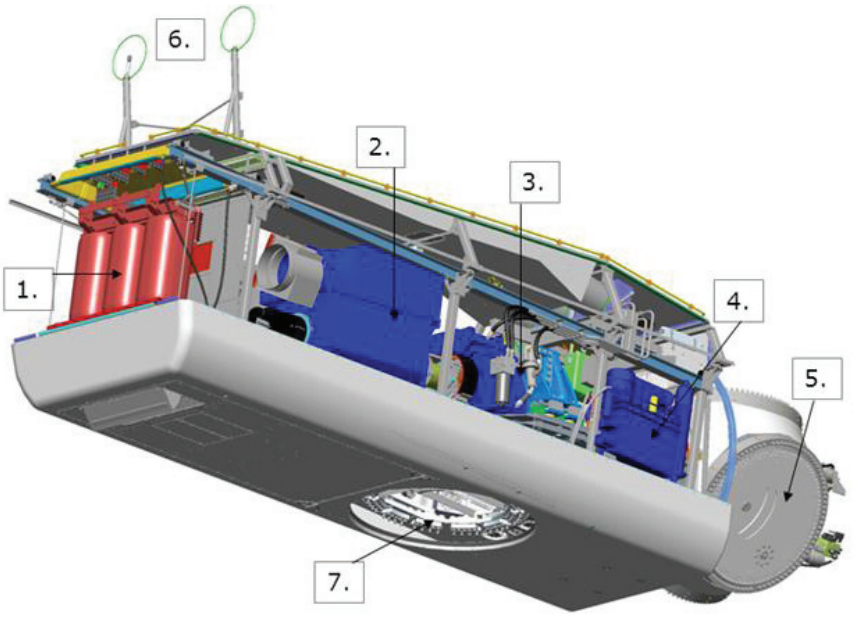

Fig 4. Parts of the nacelle: 1, transformer; 2, alternator; 3, gearbox; 4, hydraulic equipment: 5, blade pitch regulation system; 6, weather sensors; 7, yaw system.

- Specialization of plant operations
- Combining operations on a single workstation
- Simultaneous operations
- Increased flexibility
- Automation of material flows and storage
- Inspection online
- Process control and optimization
- Control of plant-level operations

For example, the assembly of the components is made along a line with different assembly stations, each specializing in a particular part of the process. To ensure that the displacement between them is efficient and minimizes space, movement and time, the use of Automated Guided Vehicle (AGV) finds in this process an optimal application. These operate without physically defined tracks and can work along the whole plant, just using a combination of calculations and signals that are identified by the sensors they carry. The precise positioning in each of the mounting stations avoids many errors and numerous loading and unloading operations. They also facilitate the process of stored once completed the assembly process. In the following figure, is shown an AVG used in an assembly factory of wind turbine nacelles.

It is also possible to apply a robot to certain processes, such as the soldier of different metal sections forming the frame, which require approximately 2000 points welding or application of adhesives and sealants to outer casing of composite. Also is possible mounting robotically of some heavy components such as the bearings that hold each of the blades on the hub. This operation requires great precision and speed, since in the hub are mounted three bearings, one for each blade (figure 6). For this operation also requires a number of auxiliary elements that facilitate the perfect positioning of the bearing, due to the small tolerance that allows adjustment.

Fig 5. Automated Guided Vehicle (AGV) used in an assembly factory of wind turbine nacelles

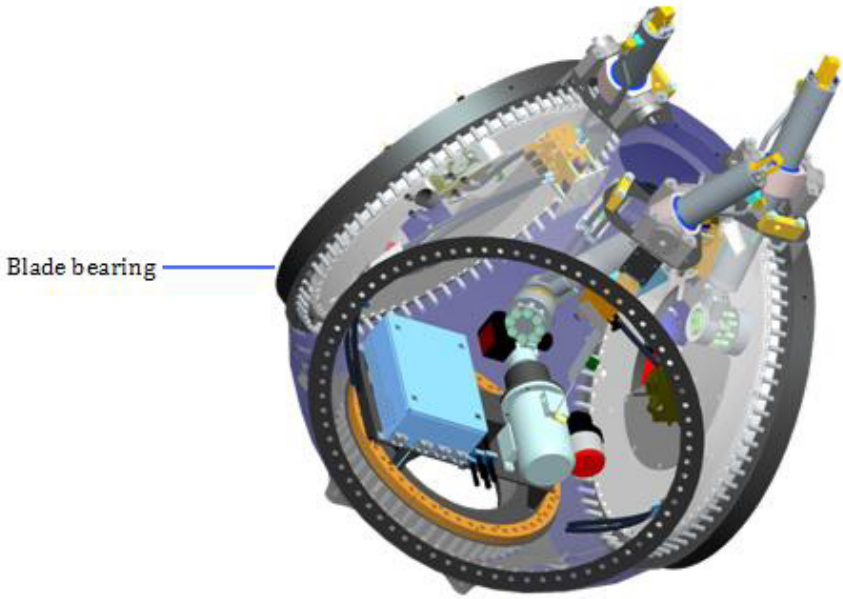

Fig 6. Blade bearing in the hub

The application of specific cranes, individually constructed for mounting heavy nacelle components (main bearings, gearbox, generator and transformer) ensures maximum efficiency, availability and security for each assembly process. Thus the raising and positioning of each component in the nacelle of accurate, secure and efficient way is provided, permitting:

- Modular concepts for handling loads
- Efficient management of small and large loads
- Precise each assembly station supply.
- High yields of rotation
- Gentle transportation of materials

Fig 7. Crane carrying a 3 mw power gearbox.

Here introduce the paper, and put a nomenclature if necessary, in a box with the same font size as the rest of the paper. The paragraphs continue from here and are only separated by headings, subheadings, images and formulae. The section headings are arranged by numbers, bold and 10 pt. Here follows further instructions for authors.

3. Conclusions

Increased automation technology in wind turbine manufacturing process is a laborious alternative and requiring substantial financial investment, but is achieved simplicity, economy and increases the final quality of each turbine. Increased reliability and cost optimization are top priorities for improving the competitiveness of wind energy sector in an increasingly competitive international environment.

References

[1]Niemüller. T, Ewert. D. Towards benchmarking cyber-physical systems in factory automation scenarios. Automation, Communication and Cybernetics in Science and Engineering. Springer International Publishing 2013/2014, pp. 665-669.

[2] P Franciosa, A Das, D Ceglarek. Design Synthesis Methodology for Dimensional Management of Assembly Process with Compliant non-Ideal Parts. Joint Conference on Mechanical, Design Engineering & Advanced Manufacturing 2014.

[3]Hazır. Ö, Haouar. M, Erel. E. Robust scheduling and robustness measures for the discrete time/cost trade-off problem. European Journal of Operational Research. 2010, pp. 633-643

[4] Methodology for the Maintenance Centered on the Reliability on facilities of low accessibility. MESIC 2013: 5th Manufacturing Society International Conference. Zaragoza, Spain, 2013.

[5]A.S. Relkar, K.N. Nandurkar. Optimizing & Analysing Overall Equipment Effectiveness (OEE), through design of experiments. Procedia Engineering, 38 (2012), pp. 2973-2980.